Study of Tug Escort for Laden Tankers
Interim Presentation

Presented to The Department of Ecology Spills Program
Oil Spill Advisory Committee
3 November 2004

THE GLOSTEN ASSOCIATES
Consulting Engineers Serving the Marine Community

Outline of Presentation

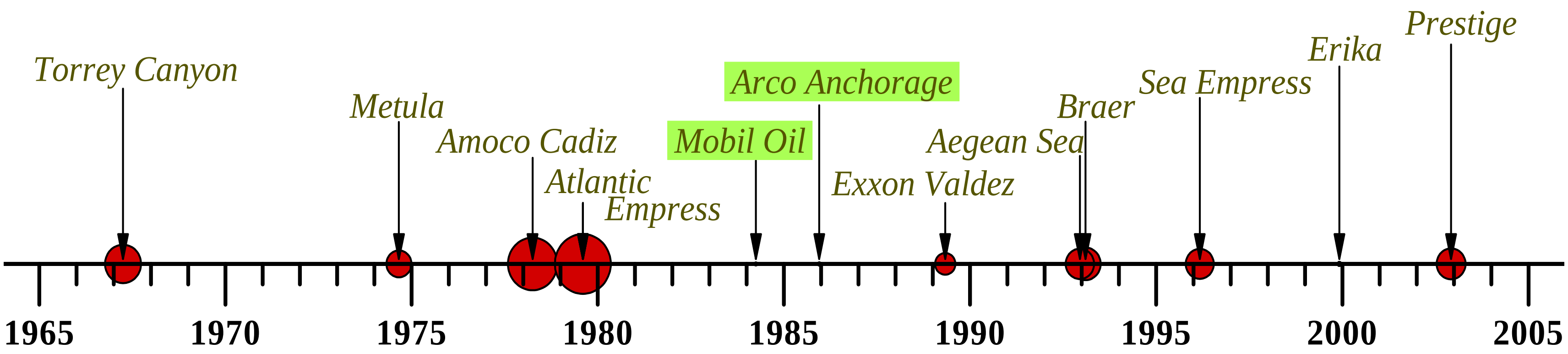
1. History of Tanker of Escort Regulations
2. RCW 88.16.190
3. OPA 90
4. Tanker Escort in other Locations
5. Socioeconomic Costs
6. Phase out of Single Hull Tankers
7. Tanker Hull Structure
8. Escort Maneuvers
9. Capabilities of Escort Tugs
10. Escort with RCW Minimum Compliance Tug
11. Probability of Grounding
12. Oil Outflow Calculation
13. Preliminary Conclusions

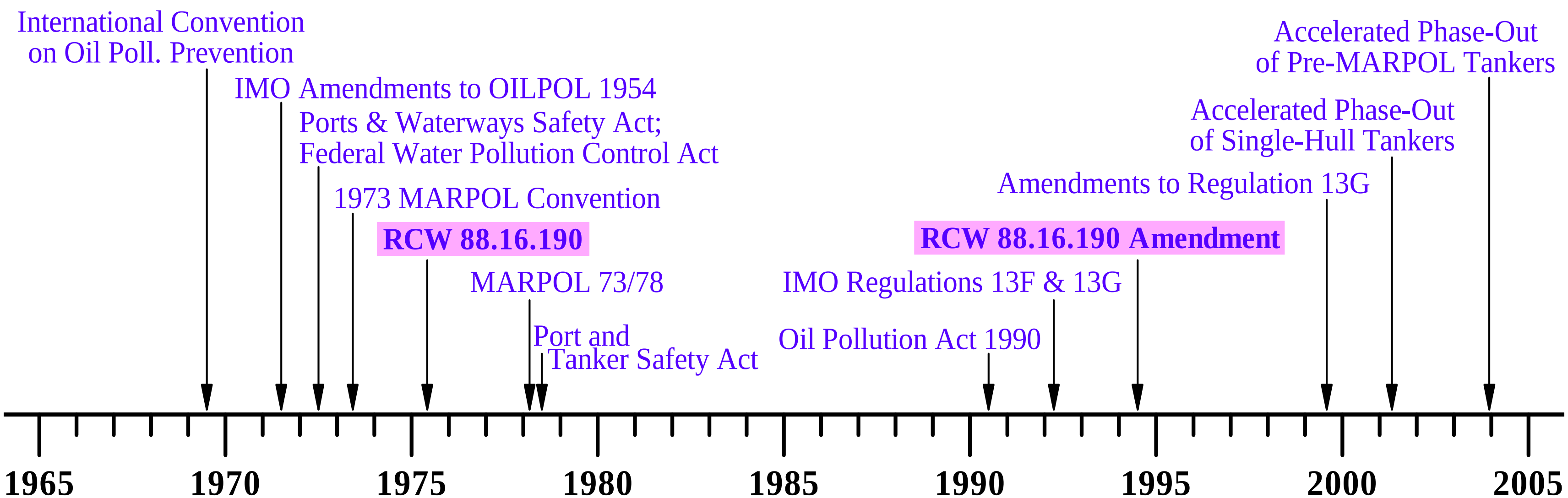
Comments, Additions, Edits and Corrections from the 3 November presentation are highlighted in yellow.

There will be a chapter in the final report discussing additional capabilities of escort tugs, including auxiliary navigation (scouting), firefighting and first response oil spill containment.

History of Oil Spills & Oil Trade Regulations

Select Oil Spills





Regulations

RCW 88.16.190

Regulations entered force in 1975 (last amended 1994):

1. Oil tankers > 125,000 DWT prohibited beyond east of line from Discovery Island light south to New Dungeness light
2. Oil tankers of 40,000 to 125,000 DWT required to have all of the following standard safety features (minimum compliance), to proceed east of above line:
   - Shaft horsepower ratio of 1 hp to each 2-½ dwt (*50,000 hp for 125,000 dwt*)
   - Twin screws
   - Double bottoms underneath all oil and liquid cargo compartments
   - Two radars (one a collision avoidance radar) in working order & operating
   - Other navigational aids as prescribed by board of pilotage commissioners

OR: Transit in ballast or under escort of tug(s) having aggregate shaft horsepower equivalent to 5% of DWT tons of tanker (*6,250 hp for 125,000 dwt*)

Issues with RCW 88.16.190

OPA 90 does not require escort of double-hull tankers; These vessels are subject only to RCW 88.16.190.

1. Is RCW 88.16.190 a reasonable requirement for double-hull tankers with redundant systems (twin-screw, twin-rudder)?
2. Is the 5% rule for tug horsepower reasonable?
3. Is a performance requirement needed, based on transit speed, etc.?
4. Is a tug capability requirement needed (single screw, twin screw, tractor).?

The basis for comparing changes to escort for redundant system tankers is the level of oil outflow risk from a single screw double hull tanker with escort. This standard was provided to the study by the WSDOE and is presumed to be the level of risk acceptable under RCW 88.16.190. For this study acceptable risk is a single screw IMO minimally compliant double hull SuezMax (150,000 dwt) tanker with RCW minimally compliant escort tug is used to determine the maximum acceptable risk.

OPA 90

Performance requirements for escort vessels :

a) An operational requirement
- operate within the performance capabilities of its escorts
- taking into consideration its speed, ambient sea & weather conditions
- all factors that may reduce the available sea room

b) A set of minimum performance requirements :
- Towing;
- Stopping ~~(superseded)~~; suspended (OPA 90 does have a minimum braking performance requirement for an escort tug)
- Holding; and
- Turning.

Other Escort Practices: North America

Puget Sound:

- Escort required under OPA 90 & RCW 88.16.190
- 15 twin-screw tugs, 11 Voith and 2 Z-drive tractors available

Prince William Sound:

- Escort required under OPA 90 & 18 AAC 75 (Alaska Oil & Other Hazardous Substances Pollution Control)
- 18 AAC 75:
  - Approved oil discharge prevention/contingency plan required for all tank vessels & oil barges in Alaska waters
  - Agreed upon speed limit of 6 knots in Valdez Narrows and elsewhere
  - Closure condition wind speed at Hinchinbrook Entrance
- 3 Voith and 3 Z-drive tractors available

Other Escort Practices: North America

San Francisco Bay:

- Escort required under CCR 14.4.4.1 (Tank Vessel Escort Regulations – San Francisco Bay)
- CCR 14.4.4.1:
  - Escort tugs required for tank vessels carrying 5,000 LT or more of cargo oil
  - Zone-dependent braking force is fn(displacement); alt. compliance OK
  - Zone-dependent speed limit of 8 or 10 knots
  - Exemption for double-hull, redundant steering & propulsion, bow thruster, and federal compliant navigation system
- 10 twin-screw tugs, 2 Voith and 18 Z-drive tractors available

Tug escort is not required if these conditions are met. (Added URL link)

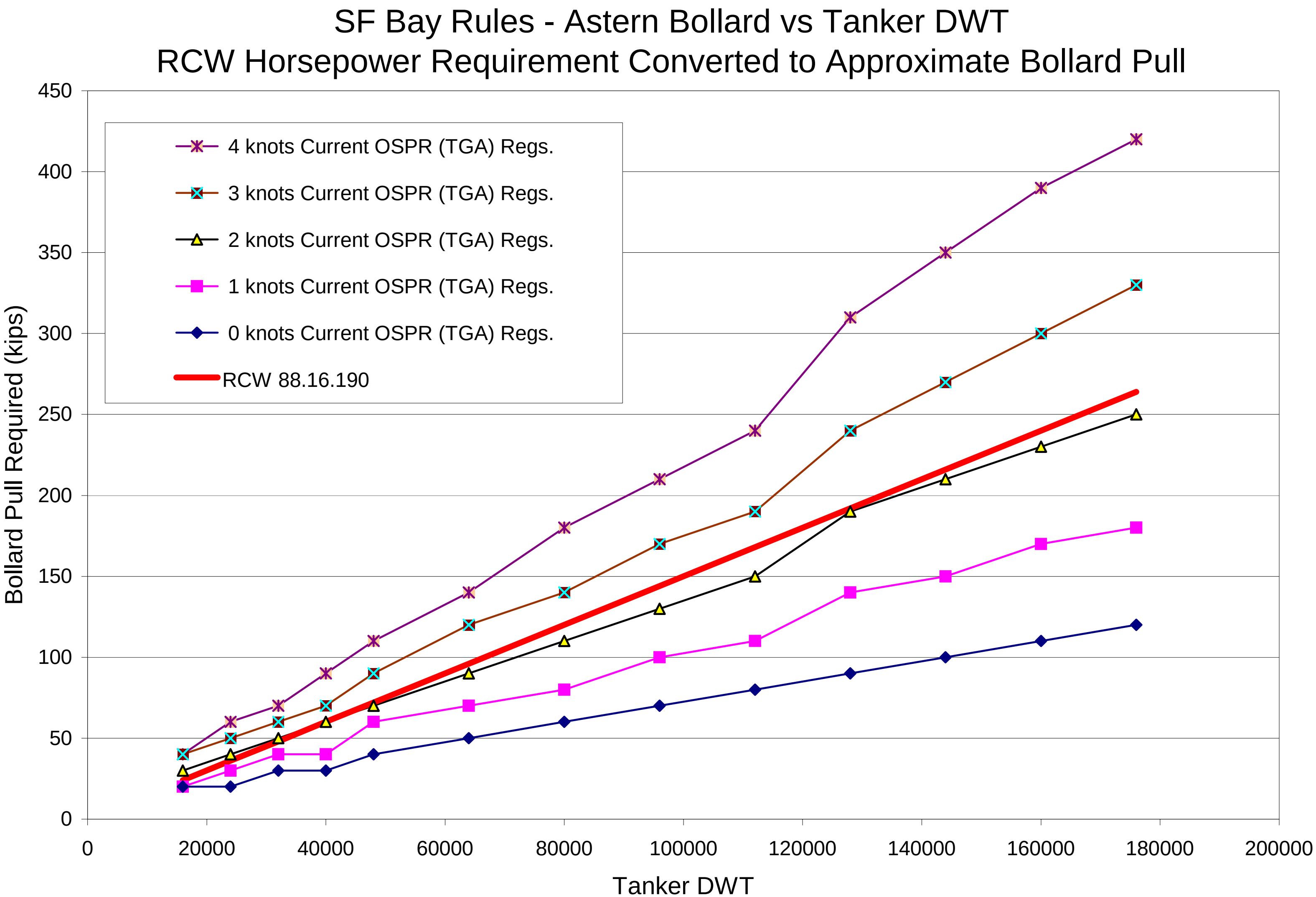
Other Escort Practices: North America

Los Angeles/Long Beach:

- Escort required under CCR 14.4.4.2 (Tank Vessel Escort Regulations – LA / LB Harbor)
- CCR 14.4.4.2:
  - Escort tugs required for tank vessels carrying 5,000 LT or more of cargo oil
  - Tug-type-dependent braking force is fn(tanker displ.); alt. compliance OK
  - Speed limit of 8 knots if < 60,000 t displacement; 6 knots if > 60,000 t displ.
  - Exemption requires double-hull, redundant steering & propulsion, bow thruster, and federal compliant navigation system
- 10 twin-screw tugs, 6 Voith and 8 Z-drive tractors available

Tug escort is not required if these conditions are met. (Added URL link)

Comparison of RCW and San Francisco Regulations



Other Escort Practices: North America

Whiffenhead, Newfoundland:

- Escort not required, but Newfoundland Transshipment Limited voluntarily practices two tug escort inbound/outbound laden tankers
- 2 Voith tractors available

Other Escort Practices: Europe

Mongstad and Rafsnes, Norway:

- Escort not required, but Port, Terminal Owners and Coastal Directorate voluntary practice escort tugs for inbound/outbound laden tankers
- More ports plan to start escorting
- 8 Voith and 13 Z-drive tractors available

Brofjorden and Gothenburg, Sweden:

- Escort not required, but Port, Terminal Owners and Coastal Directorate voluntary practice escort tugs for inbound/outbound laden tankers
- 1 Voith and 6 Z-drive tractors available

Other Escort Practices: Europe

Porvoo, Finland:

- Escort not required, but Port and Refinery Owner voluntary practice escort tugs for inbound/outbound laden tankers
- 2 Z-drive tractors available

Sullom Voe, Scotland;

Milford Haven, England

Liverpool, England:

- Escort not required, but Port and Terminal Owners voluntary practice escort tugs for inbound/outbound laden tankers
- Sullom Voe: 2 Voith tractors available;
  Milford Haven: 2 Z-drive tractors available;
  Liverpool: 5 Z-drive tractors available

Socioeconomic Costs / Impacts of an Oil Spill

Vessel blockage
Port business disruption
Commercial fishing
Tribal fishing/shellfishing
Shellfishing
Recreational fishing
National parks lost use
State parks lost use

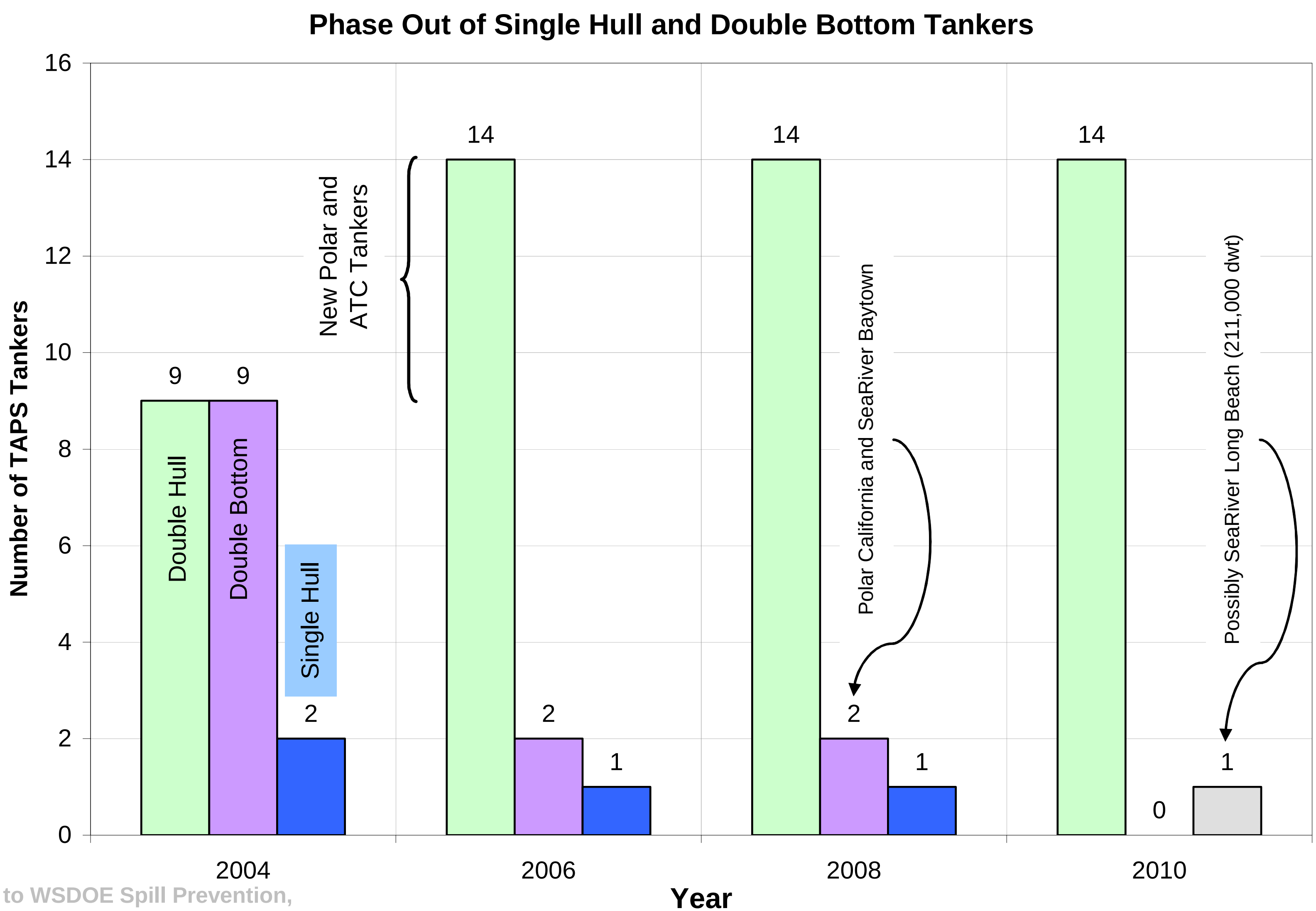
Recreational boating
National parks income
State parks income
Nature view income
Marinas
Tourism
Tribal lands
Cargo loss

Summary tables of value of resources protected will be developed and discussed in subsequent presentations and in the final report.

Response Cost Components

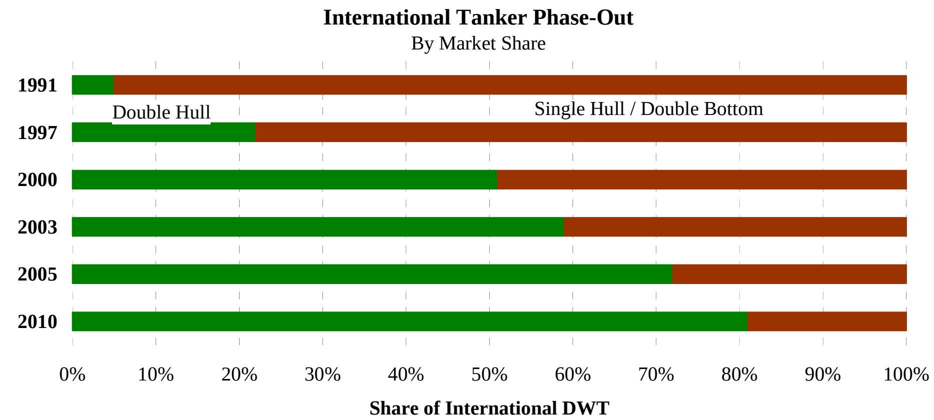
- Initial Mobilization ($500K)
- Management / Oversight ($4M - $8M)
- Salvage ($8M - $12M)
- Mechanical Equipment / Personnel
  - Days of oil slick (+ demobilize) X equipment / personnel cost
- Protective Boom ($2.84 M) per CAPS
- Dispersant Operations / Chemicals ($675K / $2.3M)
- Disposal (per bbl recovered + shoreline removal)
- Decontamination ($252 per bbl recovered)
- In Situ Burn Operations ($80/bbl burned to 1,500 bbl/day while oil >13 microns thick)

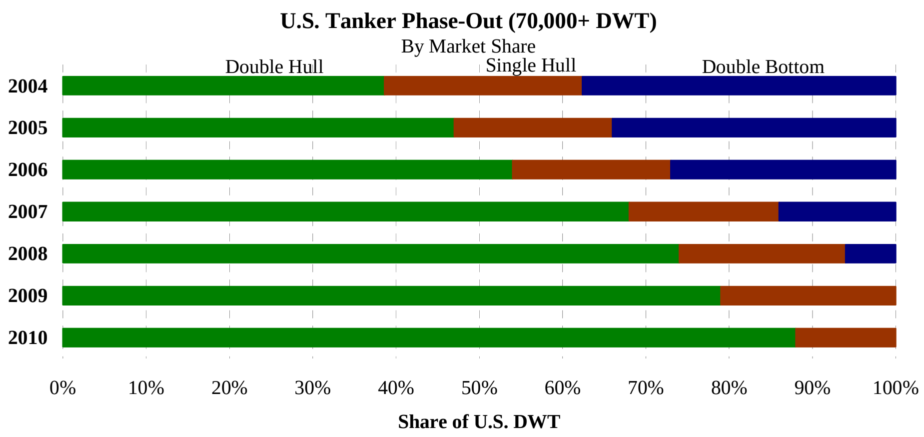
IMO MARPOL 73/78 2003 Amendment to 13G of Annex I (phase out all non double hull tankers by 2010*)

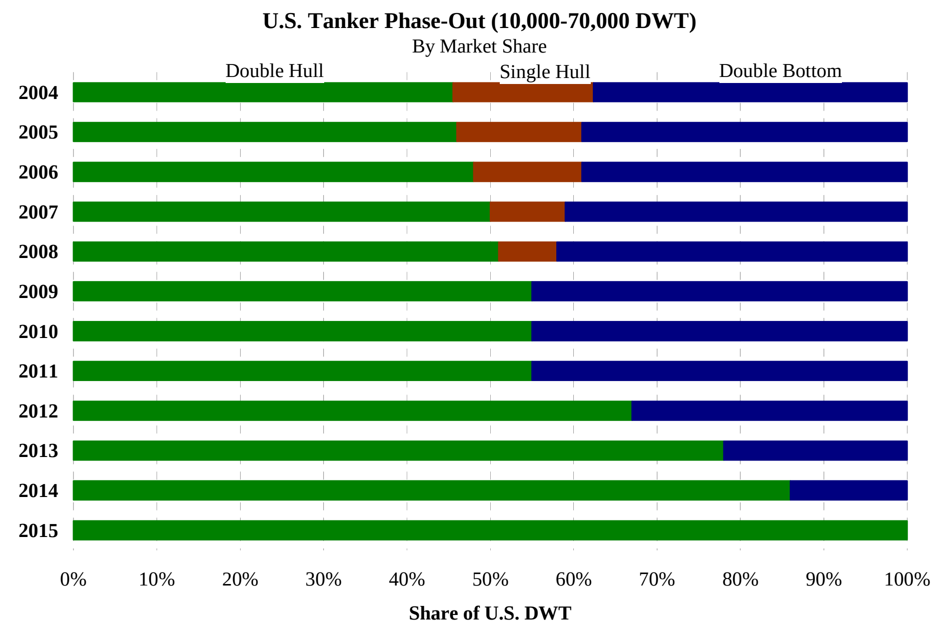


(New Slide)

Phase Out all Non Double Hull Tankers by 2010
(IMO MARPOL 73/78 2003 Amendment to 13G of Annex I)

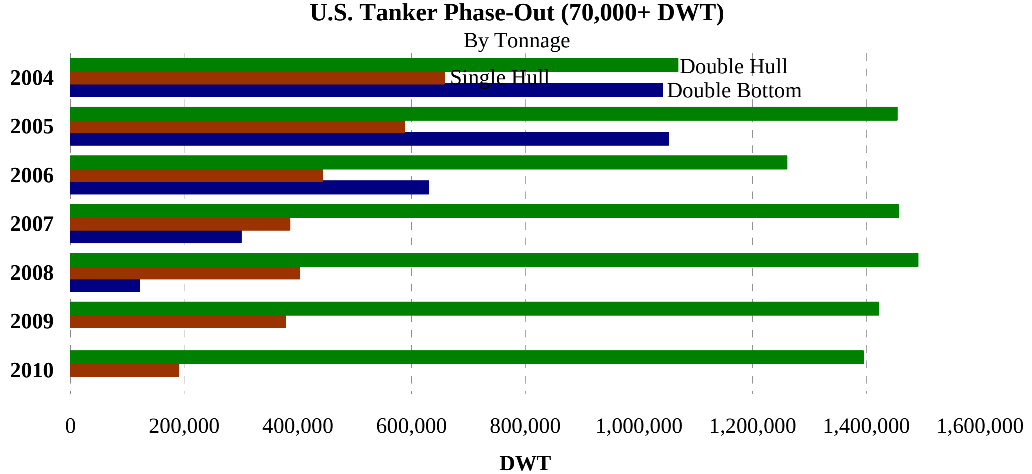


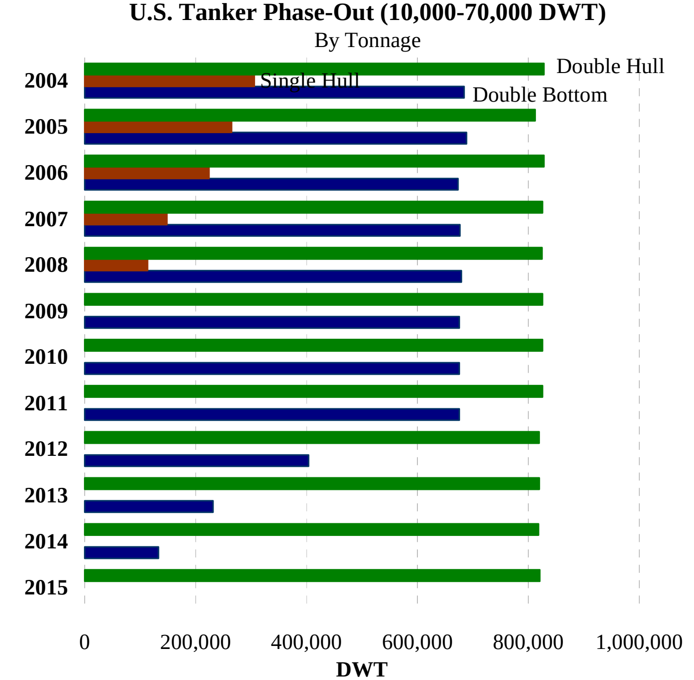


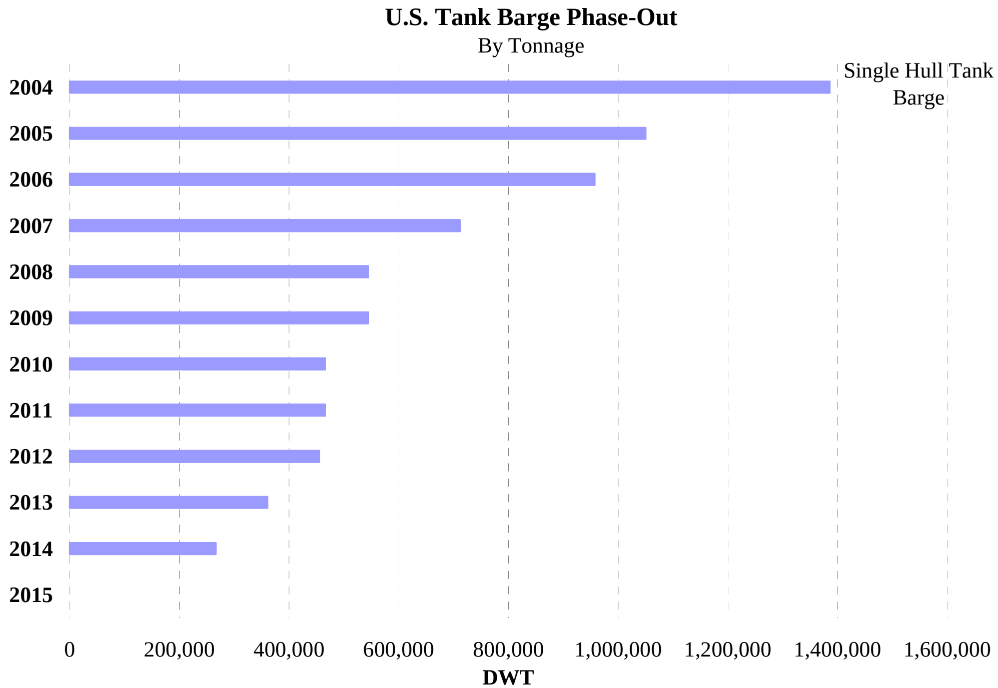


U.S. fleet phase out by 2015 proceeds in accordance with OPA 90.

(New Slide) Phase Out all Non Double Hull Tankers by 2015 (OPA 90)





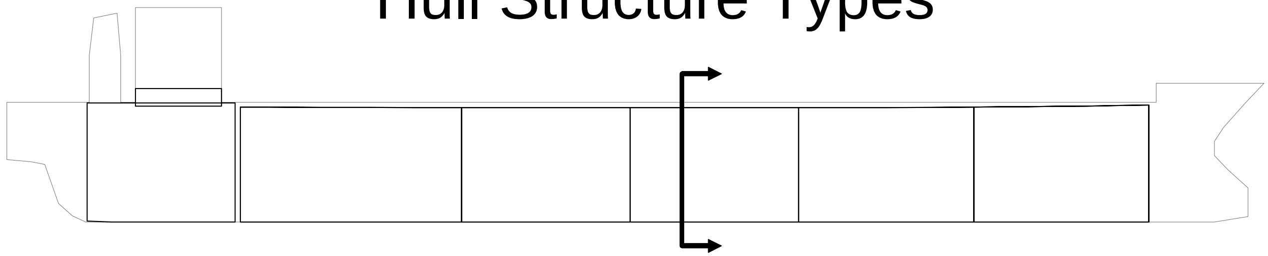


U.S. fleet phase out by 2015 proceeds in accordance with OPA 90.

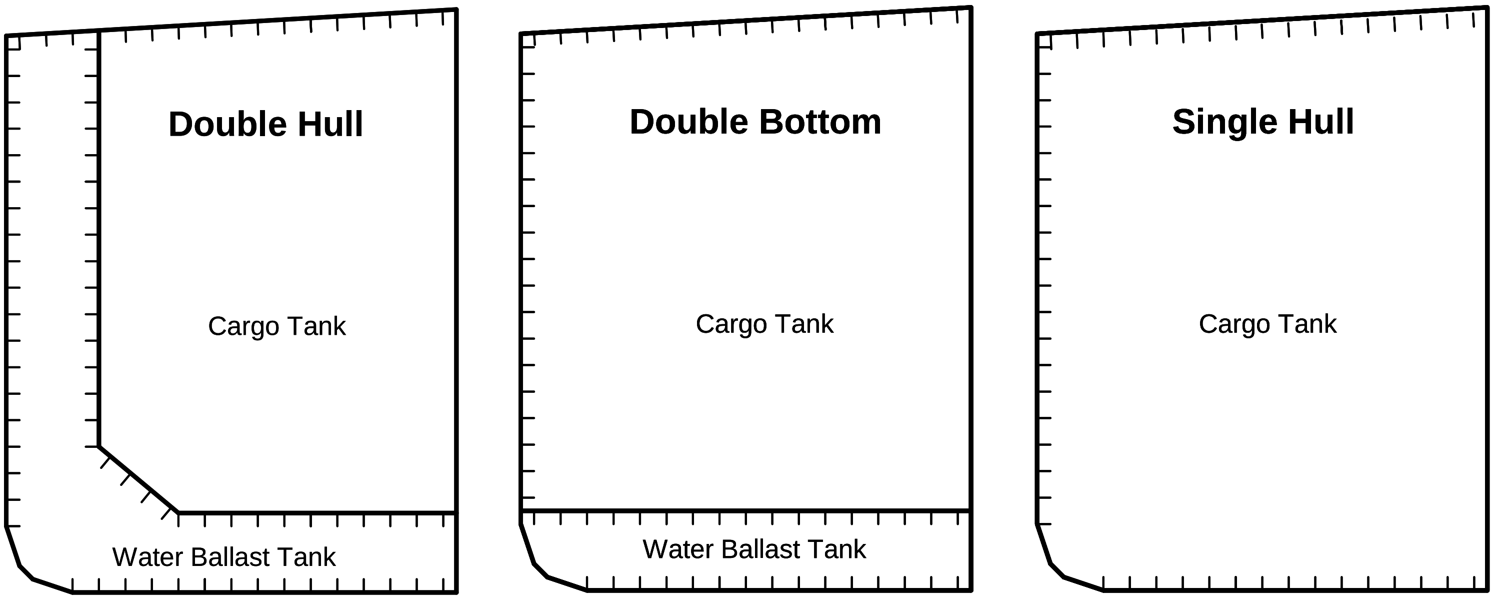
David Gray
The Glosten Associates, Inc
3 November 2004

Typical Single and Double Hull Structures

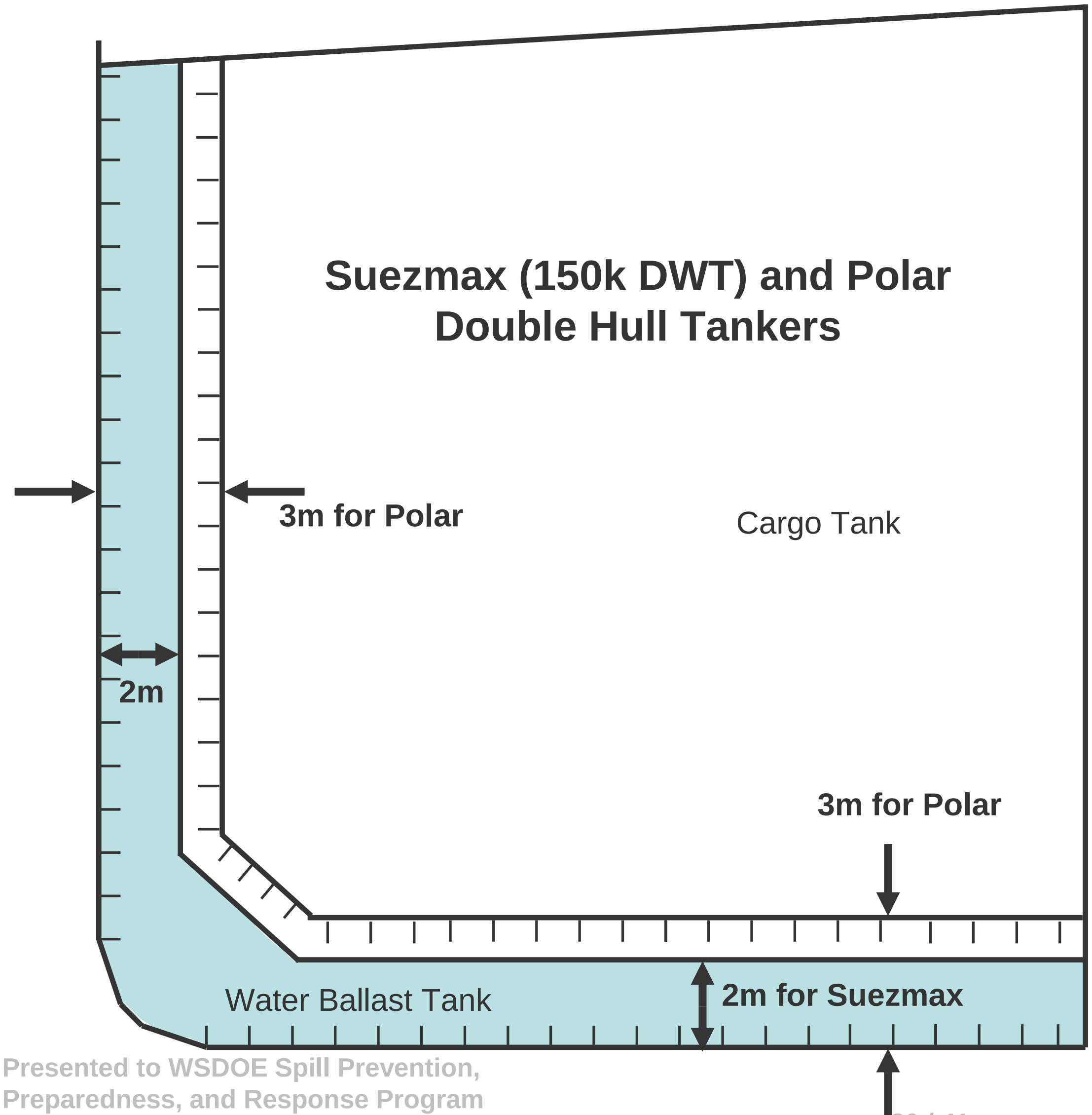
Hull Structure Types



Typical midship section of tankers entering Puget Sound



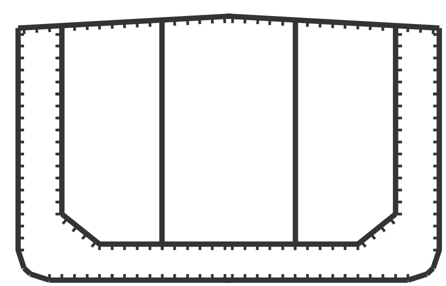
Typical and Polar Millennium Double Hull Spacing



Double Hull Dimensions
Suezmax = 2m*
BP ATC = 2.7m
Polar = 3.0m

* Future MARPOL regulations to be adopted in 2006 require oil outflow performance requirements.

- Approximately 2.5m double hull for 6x2 cargo arrgt.
- Approximately 2.3m double hull for 6x3 cargo arrgt.

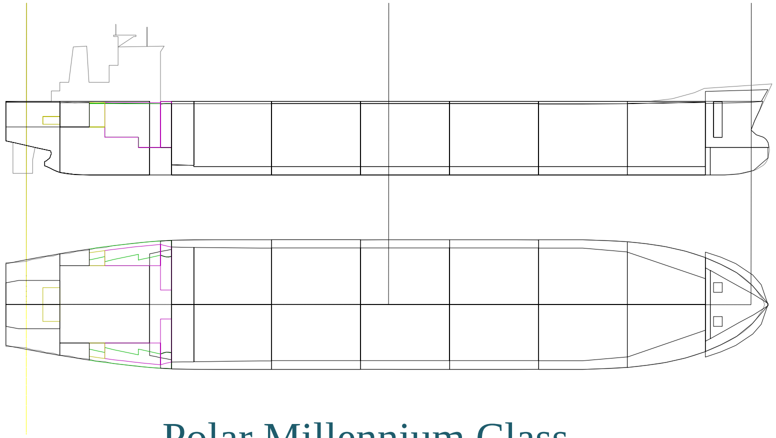


Loading of Polar and ATC Tankers

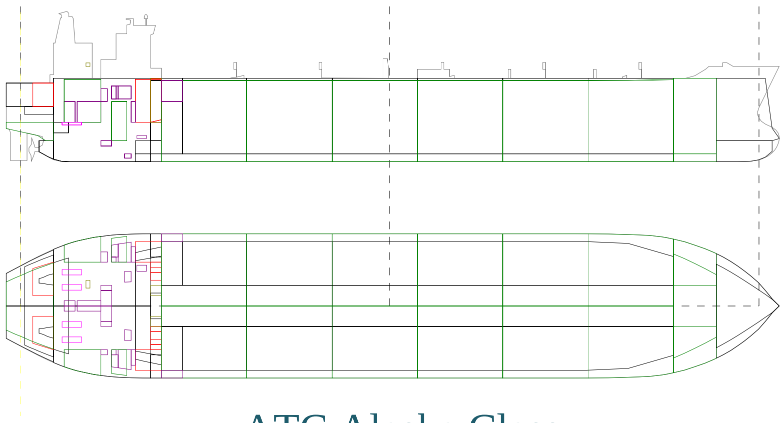
Polar Millennium Class is ~~148,000 dwt~~ 142,000 dwt

ATC Alaska Class is ~~188,000 dwt~~ 185,000 dwt

Each vessel is loaded to a 125,000 DWT for Puget Sound deliveries.
Tanks 2, 3, 4 and 6 loaded to 98%.
Tanks 1 loaded to 65%.
Tanks 5 loaded to 77%

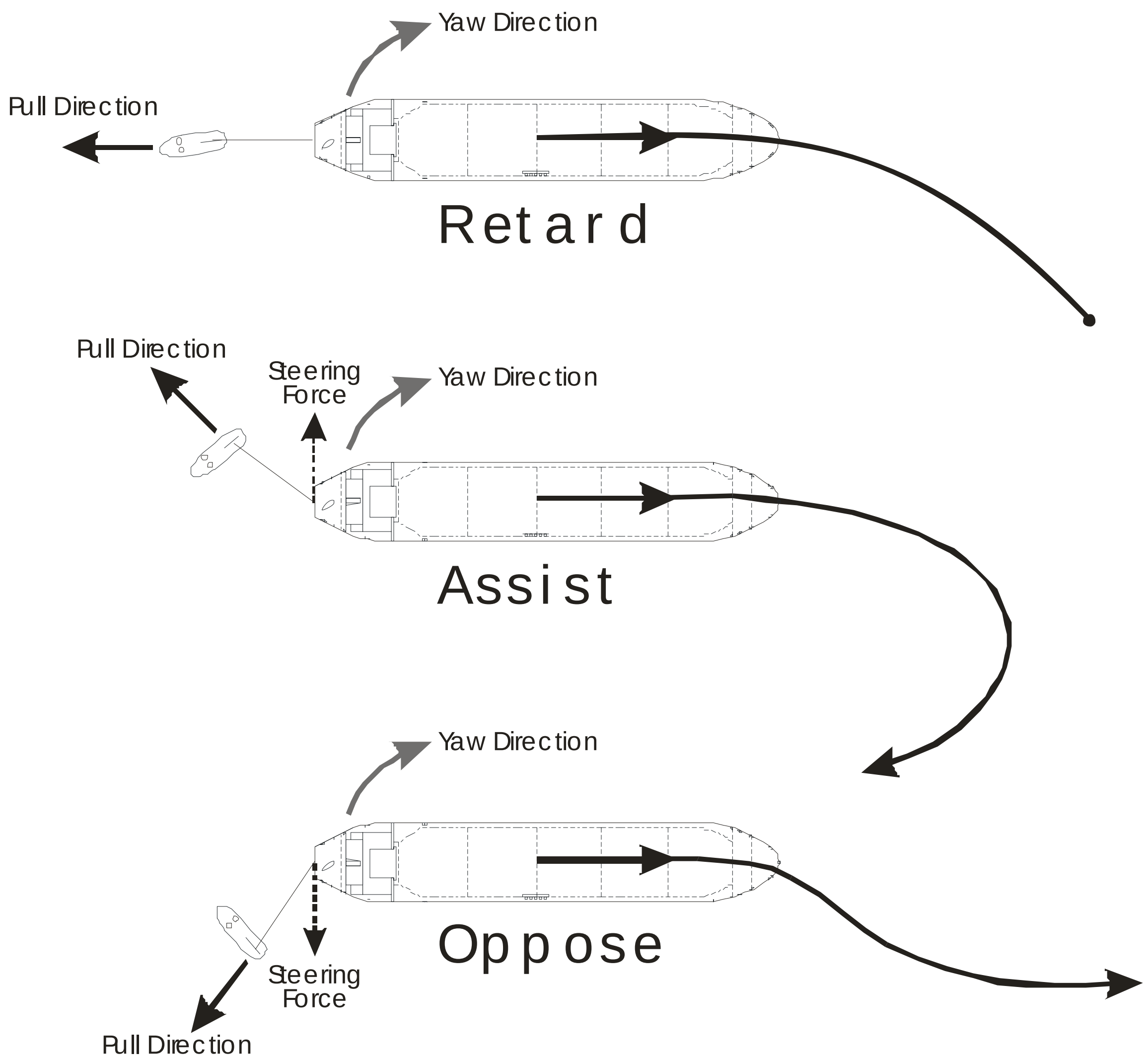


Polar Millennium Class



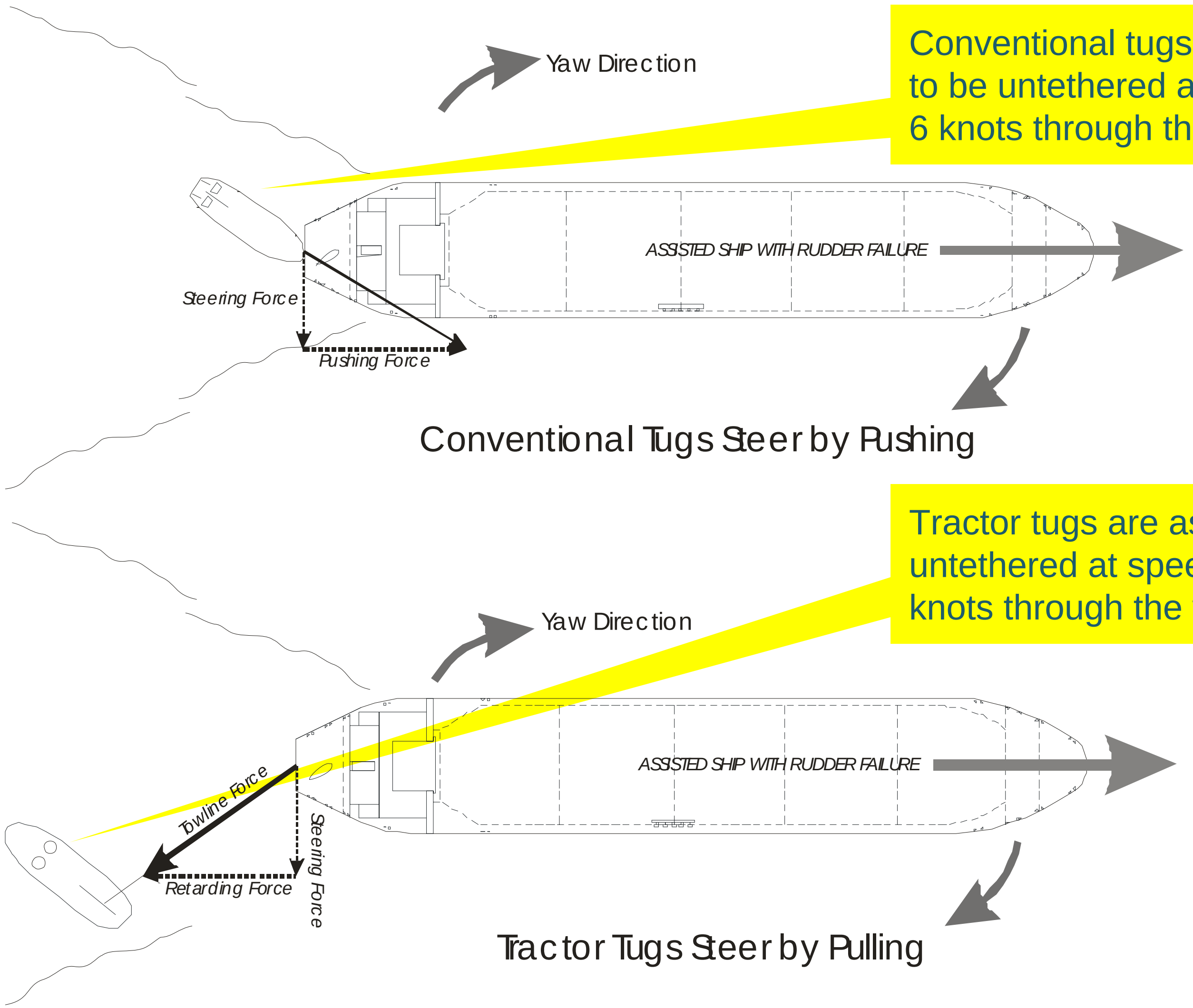
ATC Alaska Class

Escort Tug Emergency Response Maneuvers



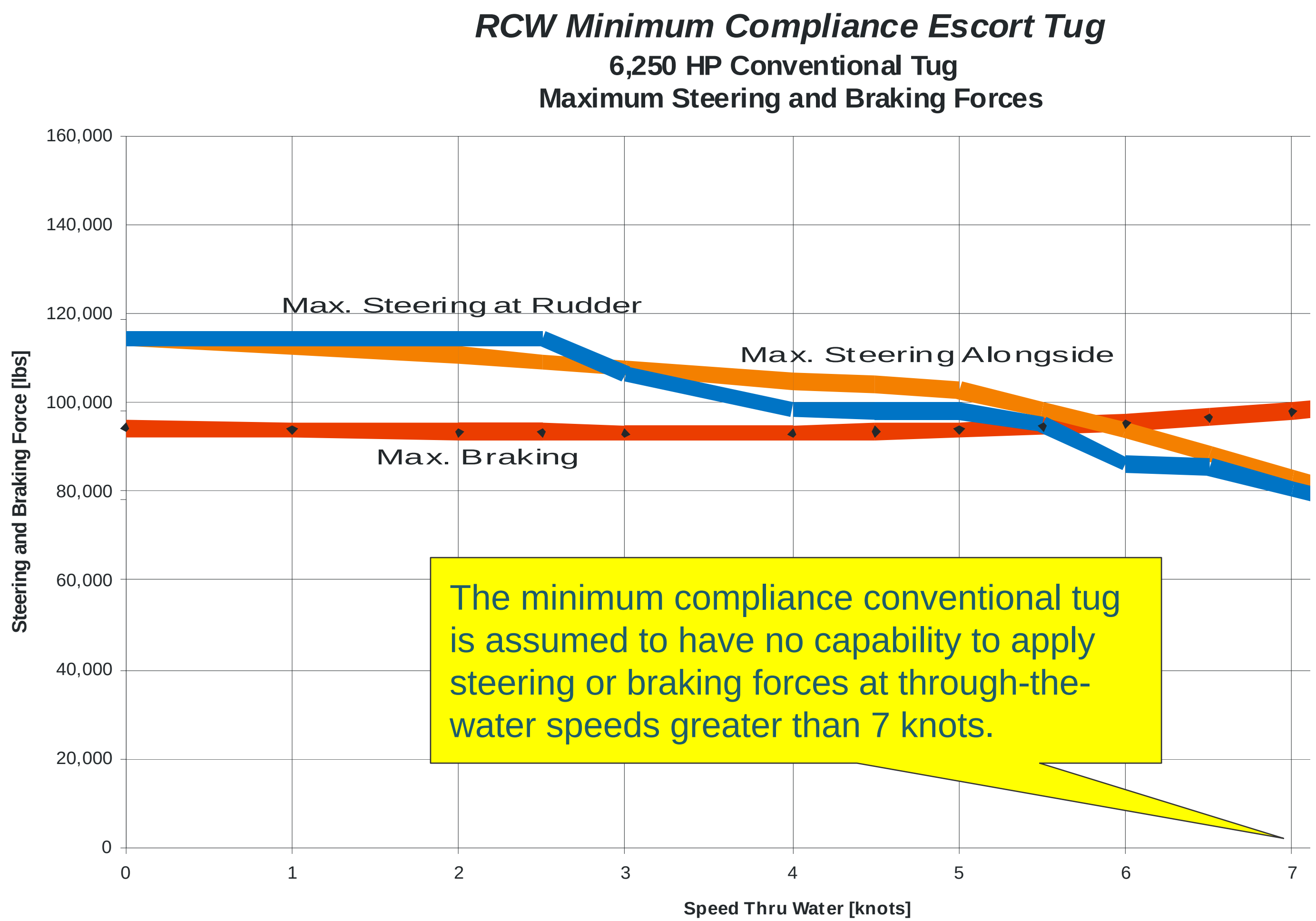
Comparing Conventional and Tractor Tug Emergency Response Maneuvers

Conventional tugs are assumed to be untethered at speeds above 6 knots through the water.

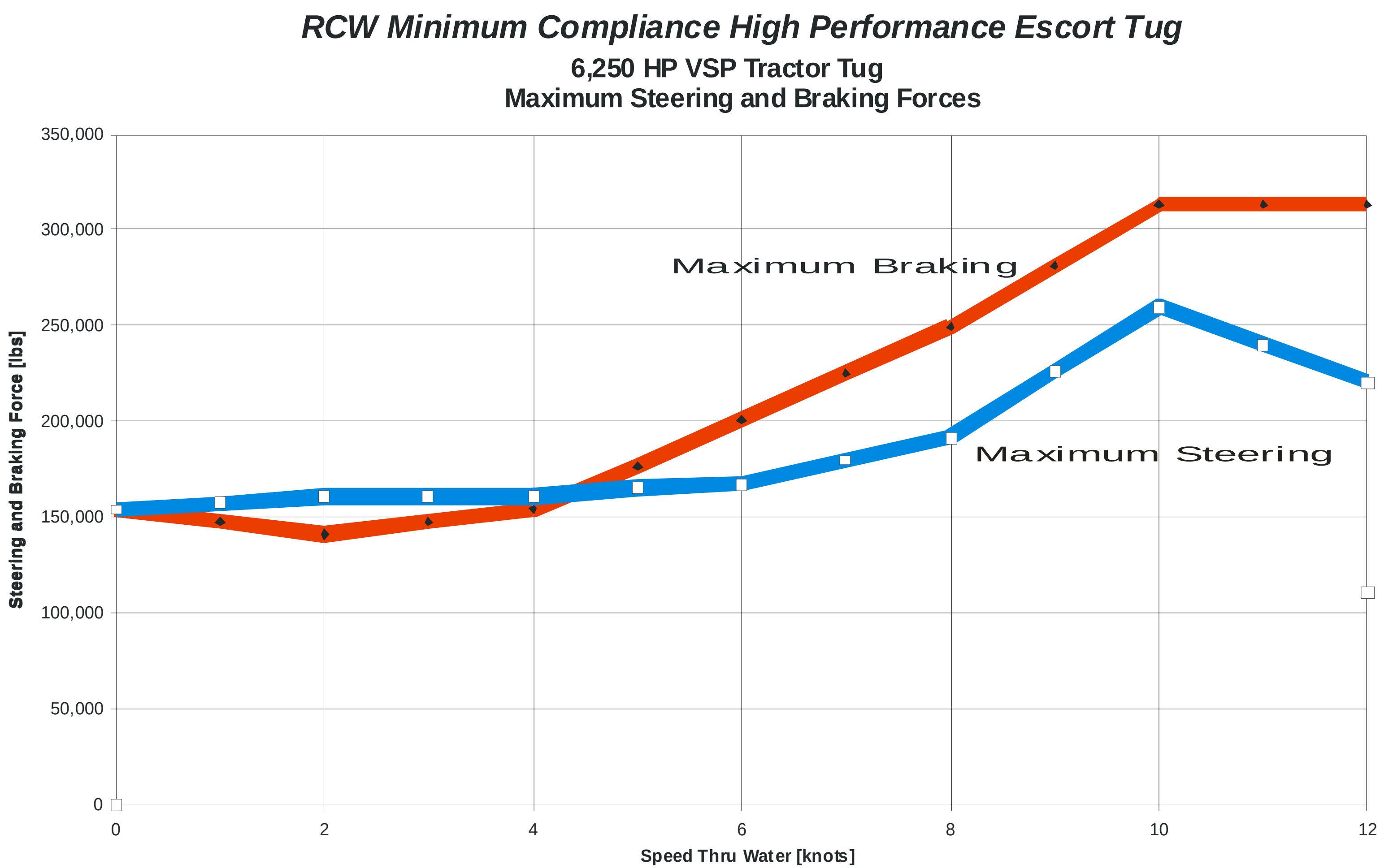


Tractor tugs are assumed to be untethered at speeds above 12 knots through the water.

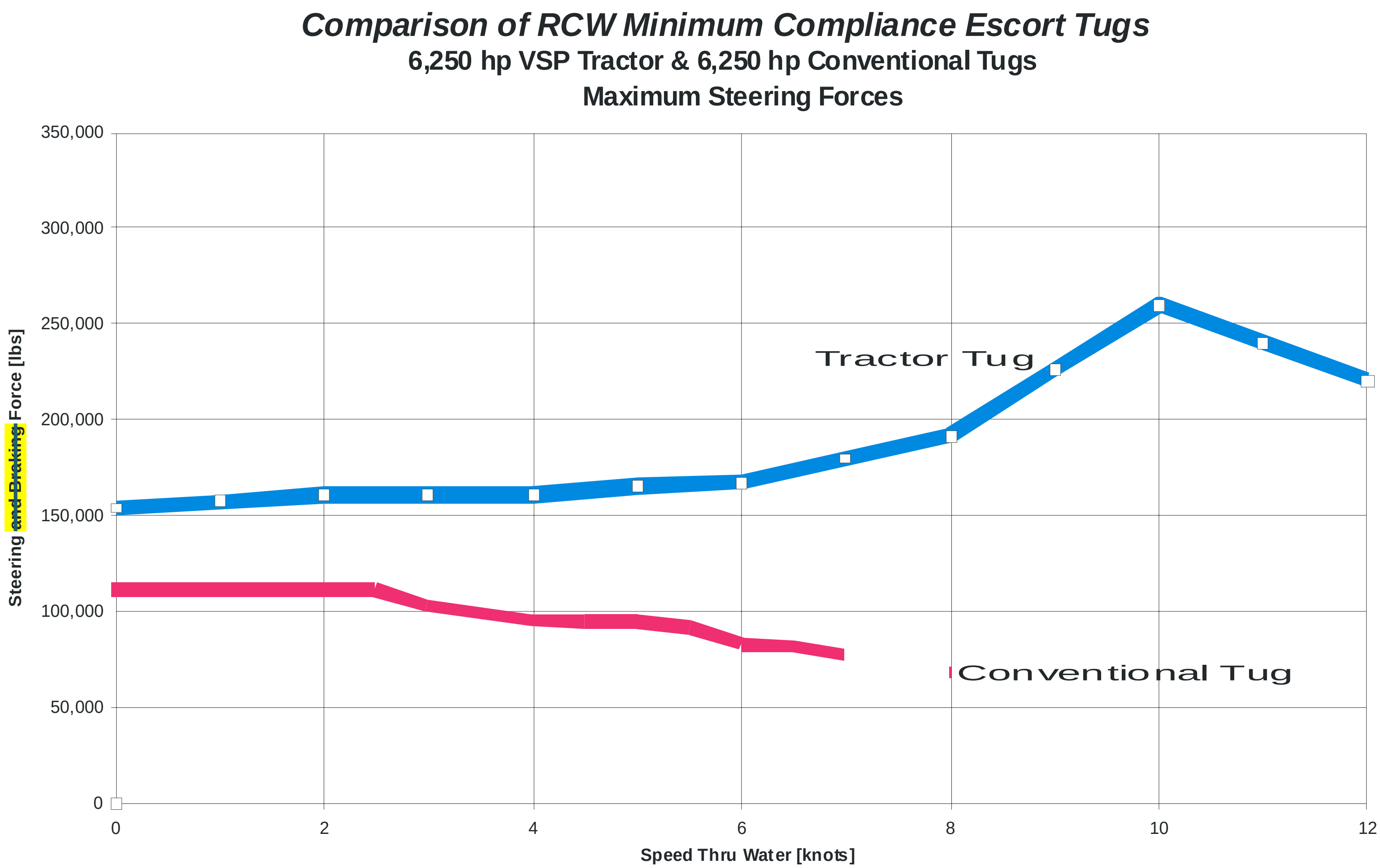
Capability of RCW Minimum Compliance Escort Tug



Capability of RCW Minimum Compliance High Performance Escort Tug



Comparison of RCW Minimum Compliance Escort Tugs



Escort with RCW Minimum Compliance Tug

Tanker Escort with RCW Minimum Compliance Tug & a Single Screw Tanker can be Successful in Preventing a Grounding

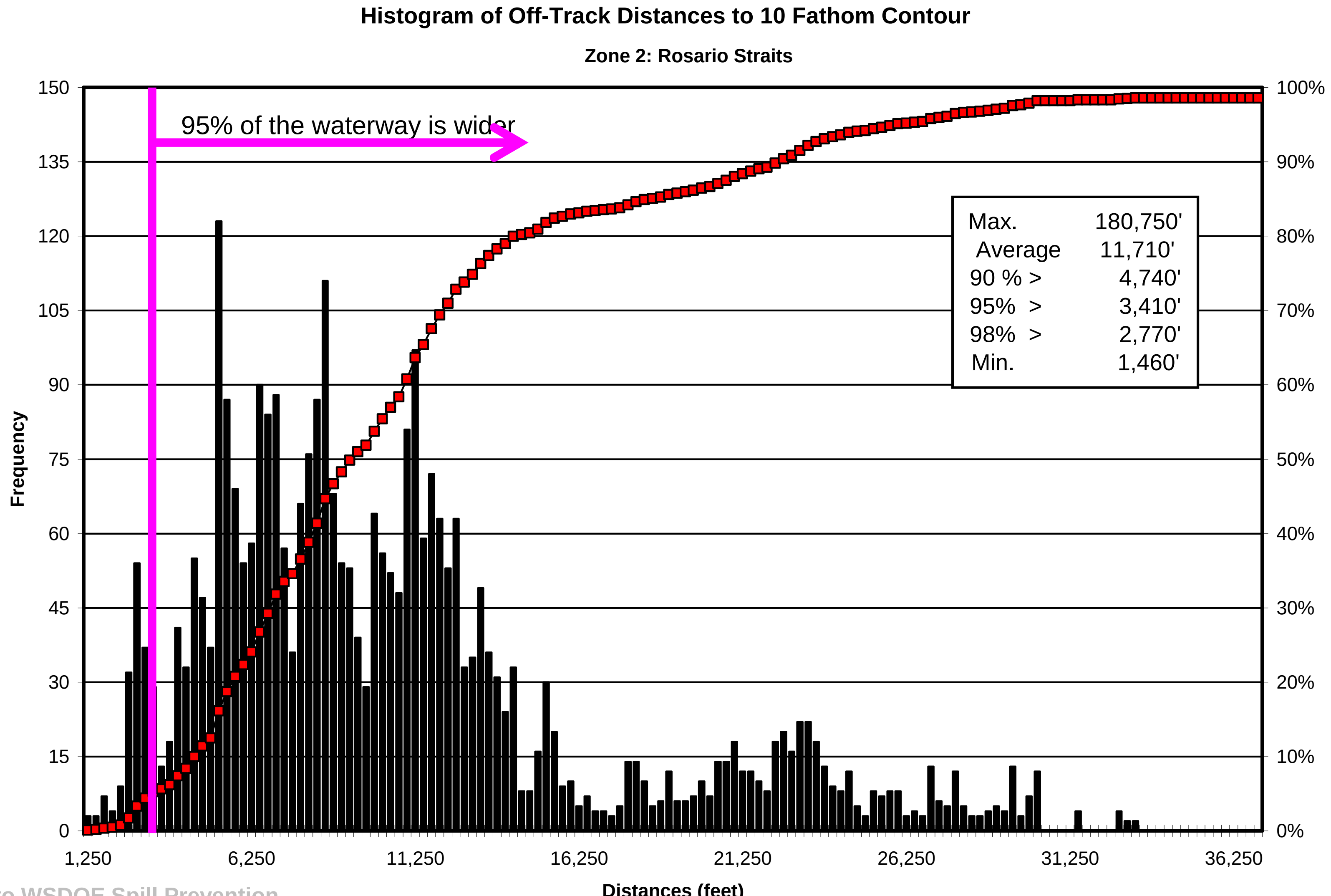
IF (*all of the following are implemented*):

- Tanker is transiting at the appropriate speed for the waterway
- The failure occurs in the stretch of the waterway that is wider then the 95 %tile width or the tanker slows down to match the tug's capability during the narrower portion.
- Tanker propulsion is shutdown within 30 seconds of failure
- Failure condition is correctly understood within 60 seconds of failure
- The best corrective maneuver (out of three possible maneuvers) is chosen
  - The best corrective maneuver depends on tanker speed
  - The best corrective maneuver depends rudder failure angle
- Tug starts corrective maneuver within 120 seconds of failure
- The tug executes the corrective maneuver using maximum capability

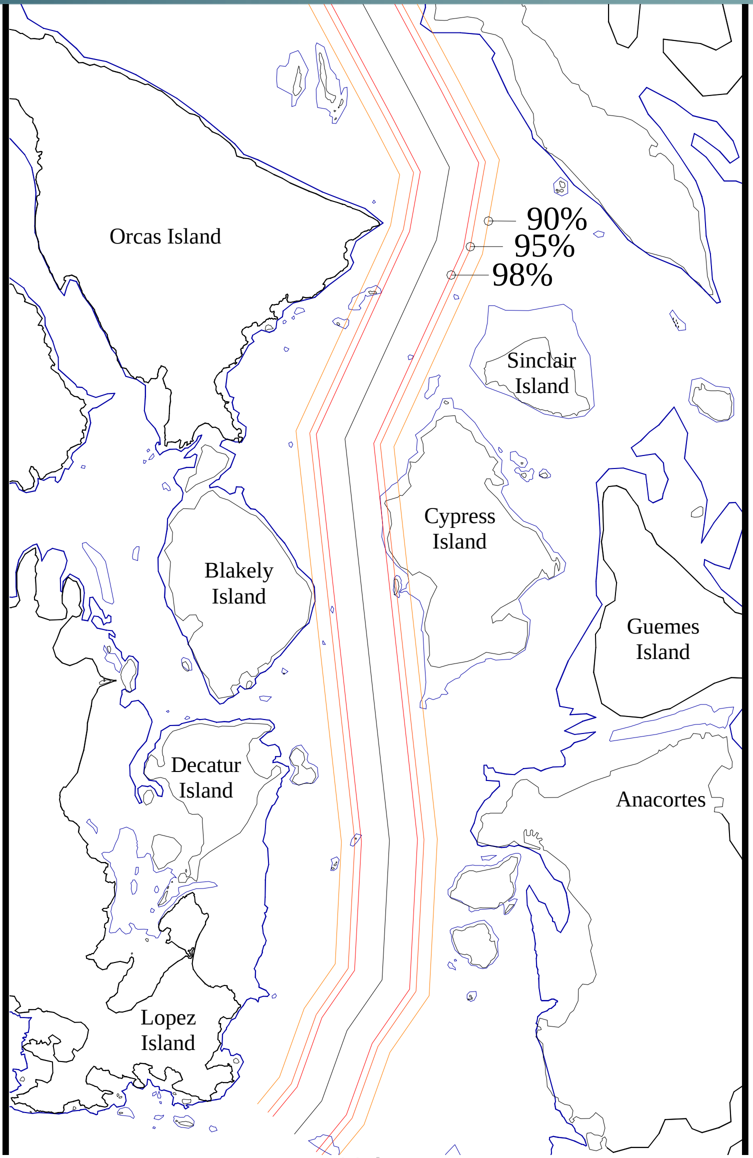
An Engineered Solution Exists that can Prevent a Grounding

However, Human Factors Govern the Probability of Success

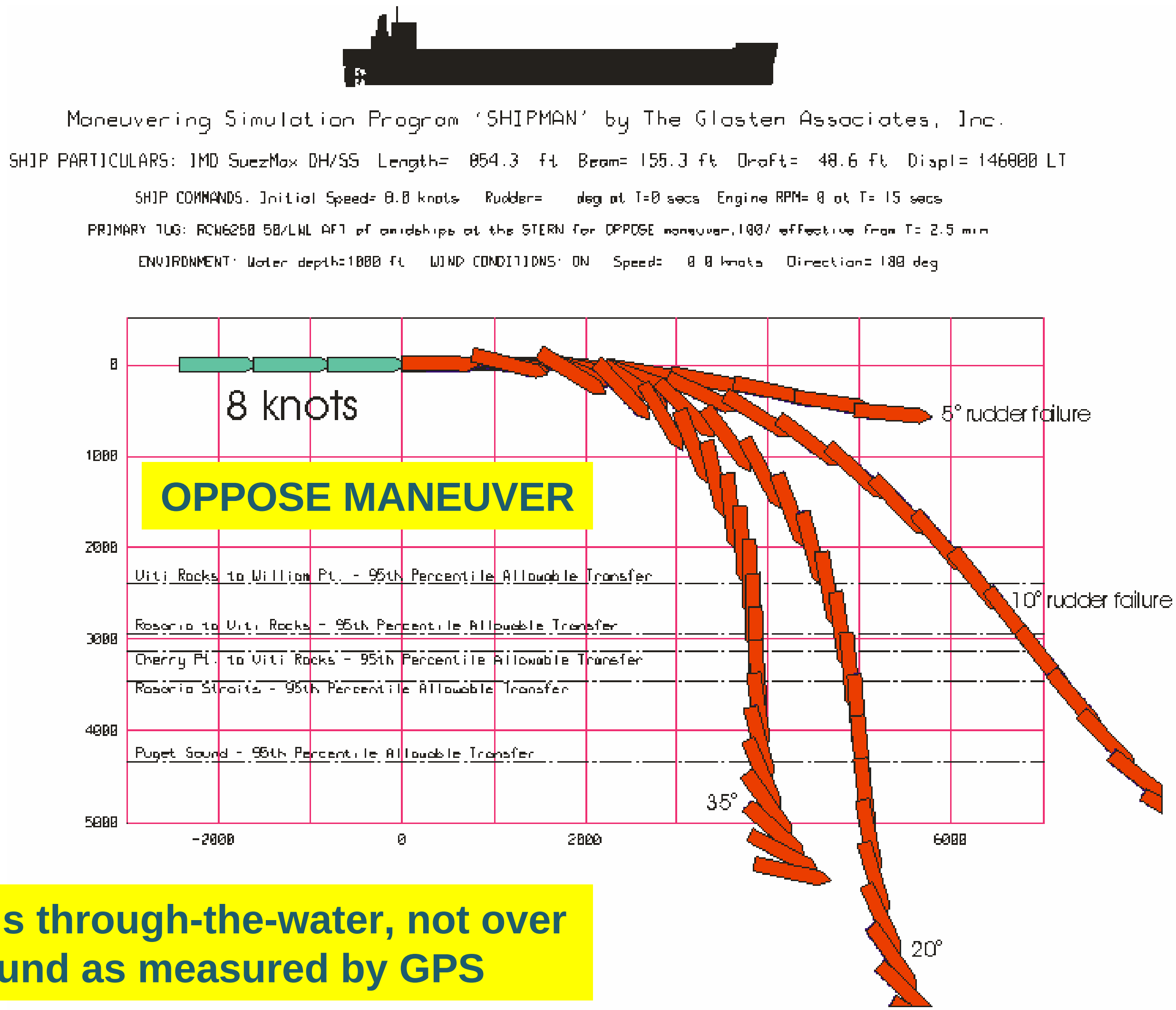
Channel Width Statistics – Rosario Straits



Channel Width Statistics – Rosario Straits

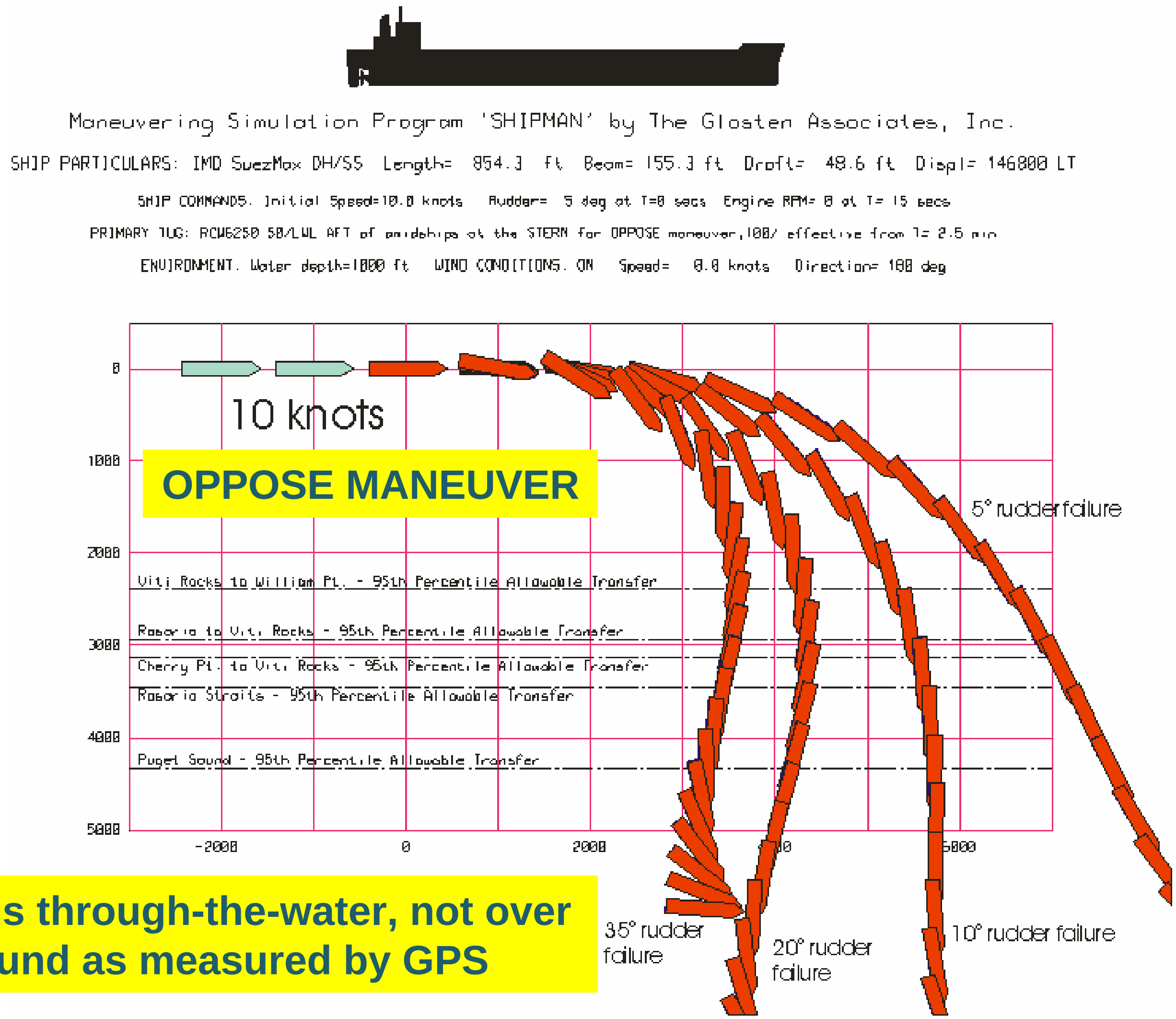


RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



Speed is through-the-water, not over the ground as measured by GPS

RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



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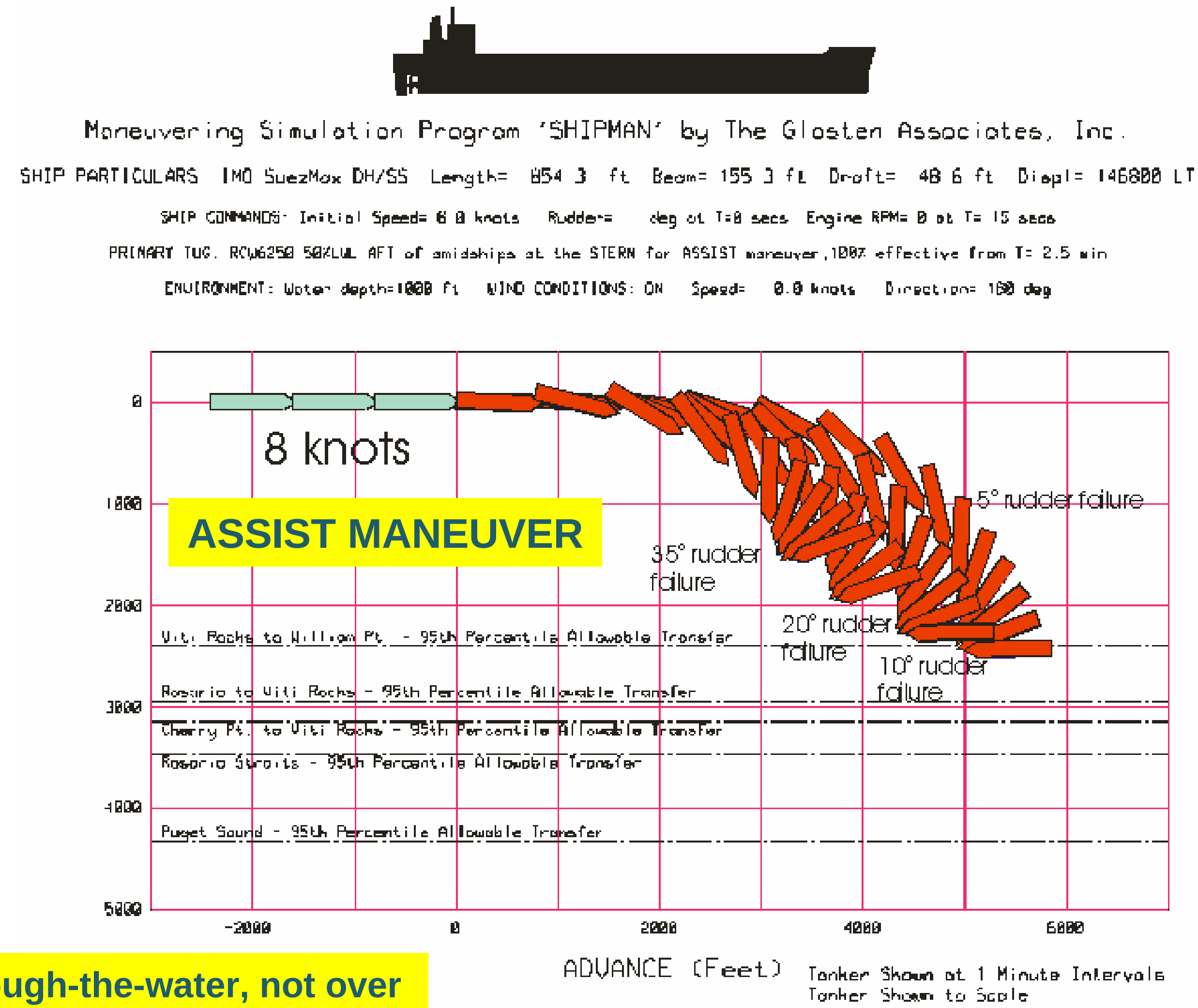
RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



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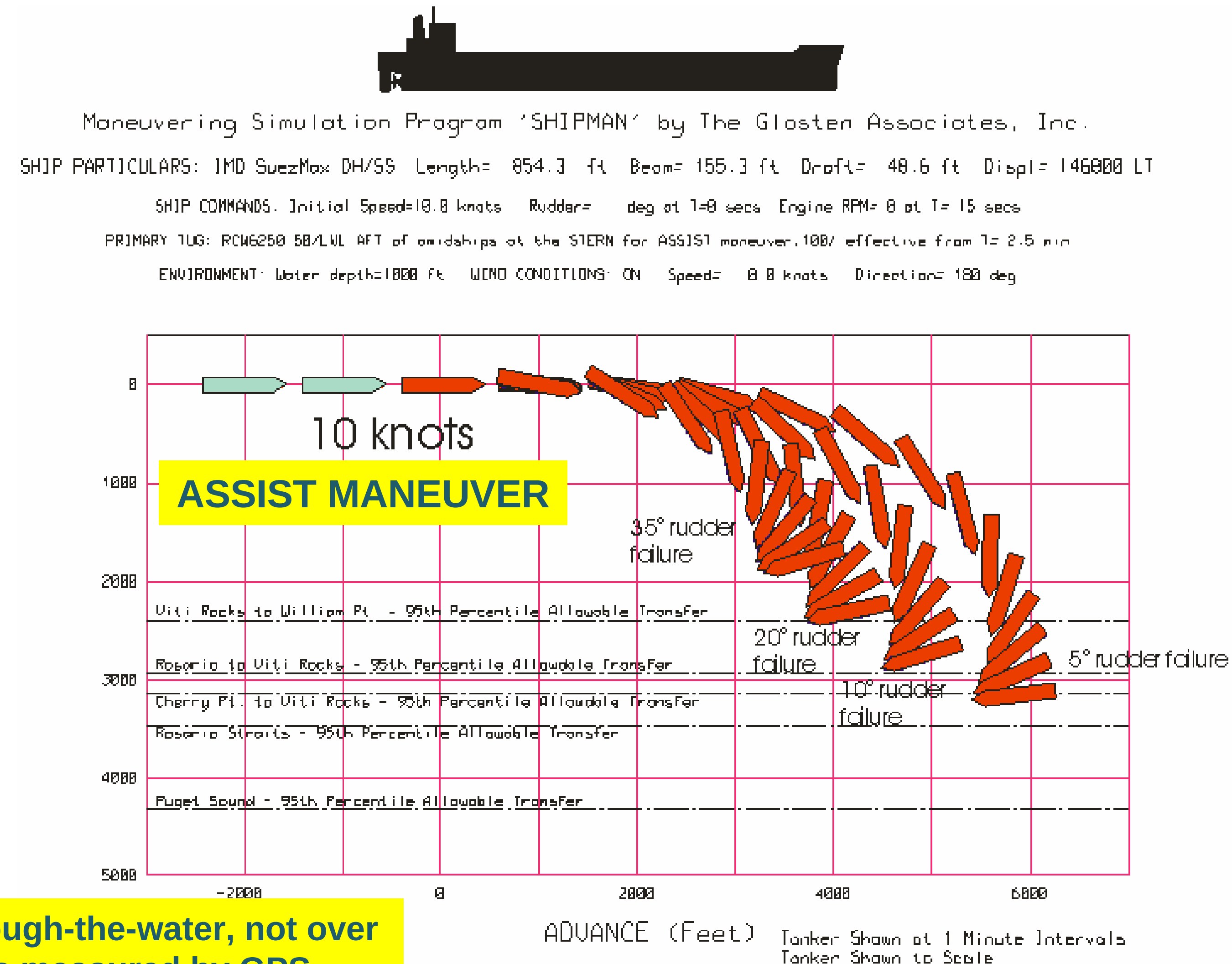
RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



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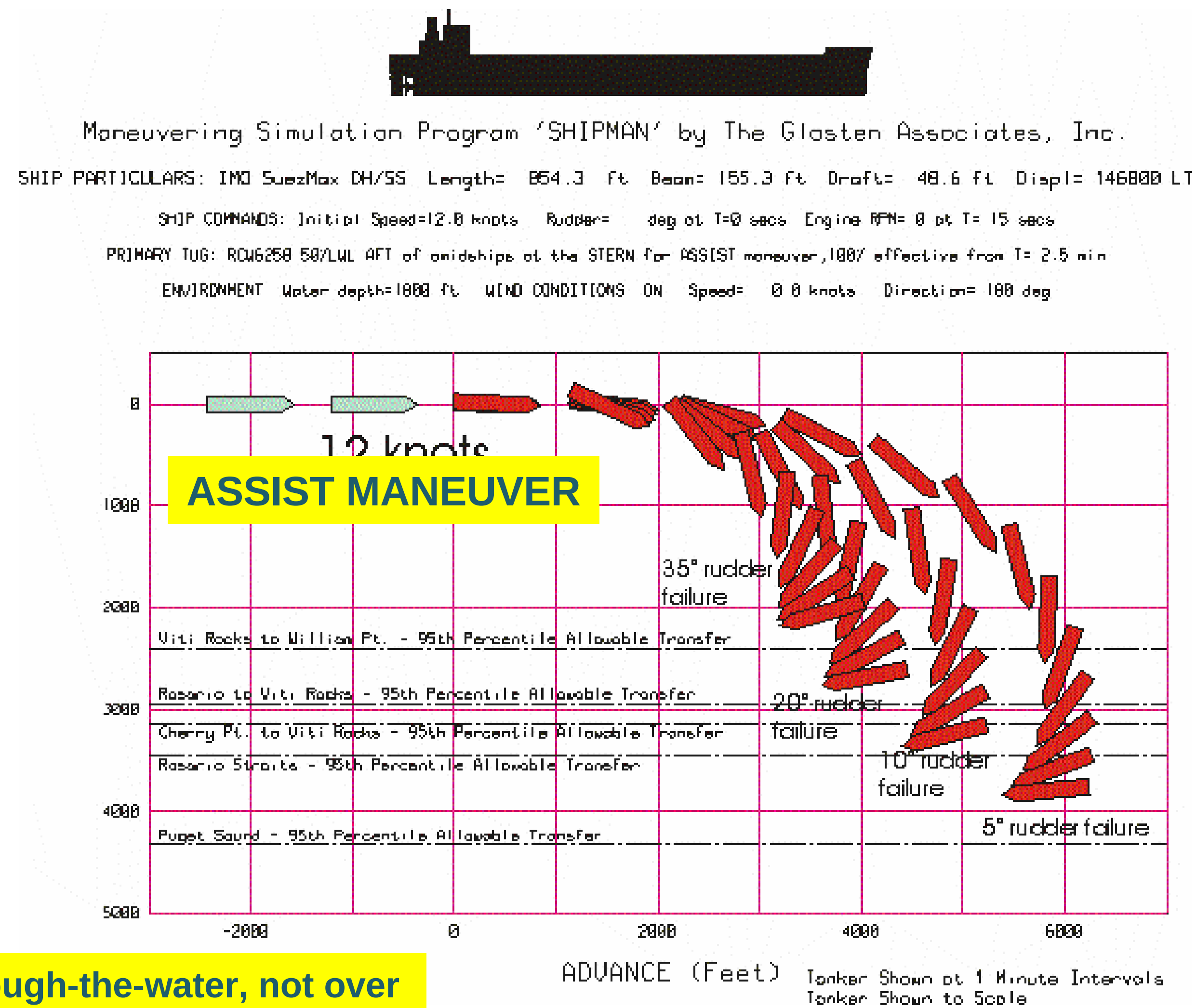
RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



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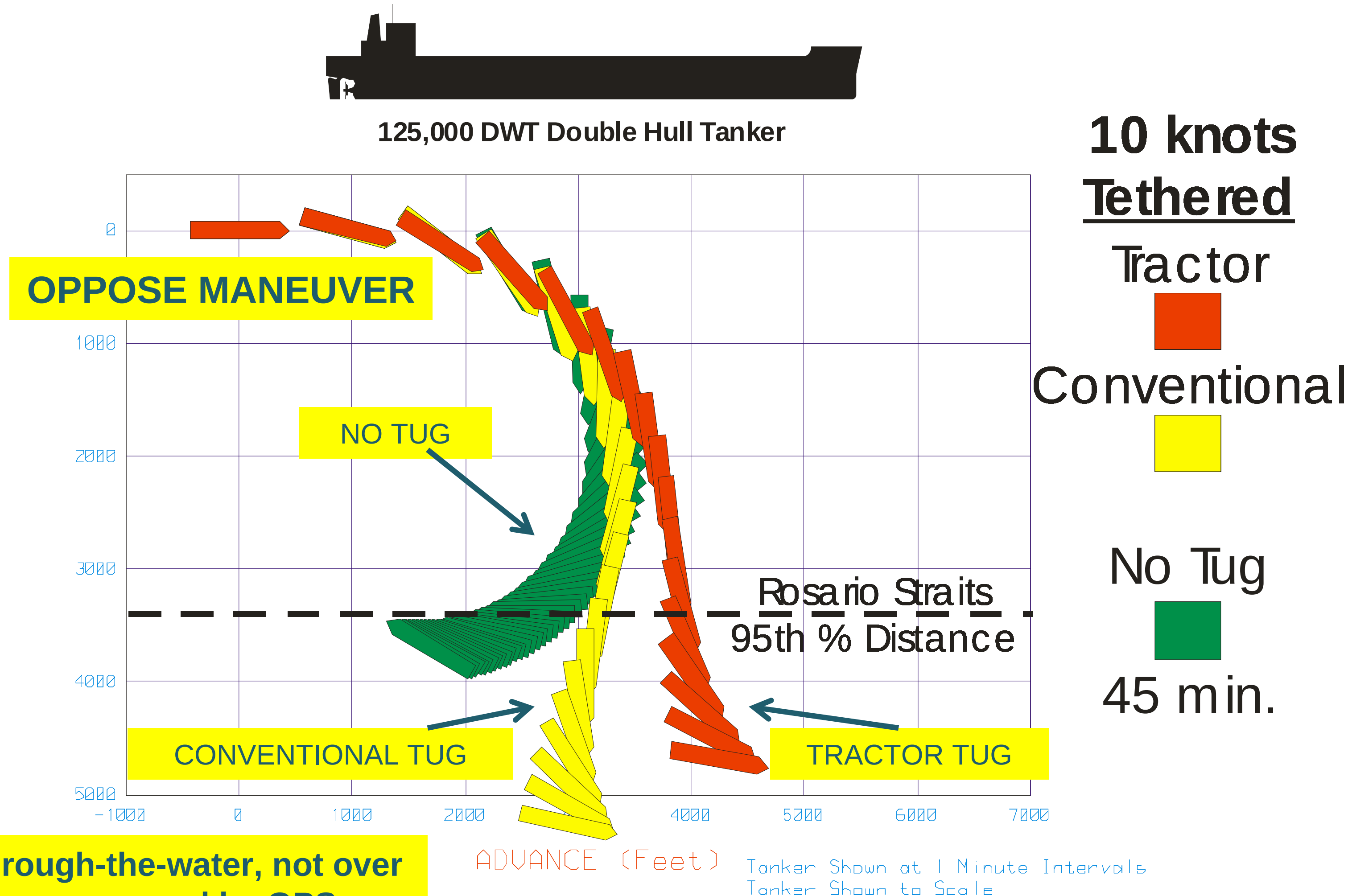
RCW Minimum Compliance Tug – Oppose Maneuver – SS Suez Max. Tanker



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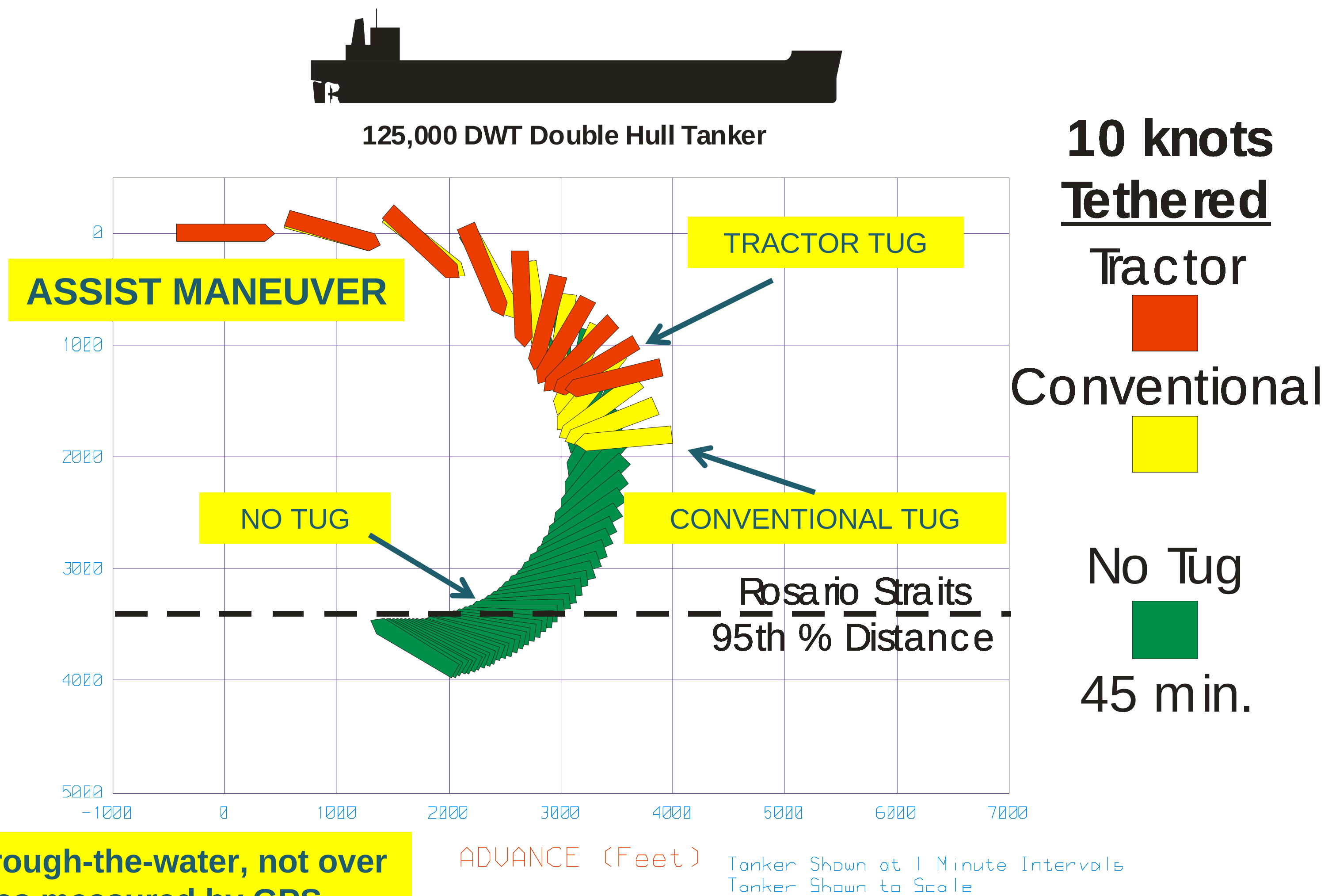
RCW Minimum Compliance Tug – Assist Maneuver – SS Suez Max. Tanker



Speed is through-the-water, not over the ground as measured by GPS

Escort with RCW Minimum Compliance Tug – Single Screw Tanker

Tanker Escort with RCW Minimum Compliance Tug & a Single Screw Tanker can be Successful in Preventing a Grounding

Examples:

- 5º Rudder Failure at 8 kts in Rosario Straits – Oppose Maneuver is Successful
- 5º Rudder Failure at 10 or 12 kts in Rosario Straits – Oppose Maneuver is NOT Successful
- 10º Rudder Failure at 8 kts in Rosario Straits – Oppose Maneuver is Successful
- 5º – 35º Rudder Failure at 8 kts in Rosario Straits – Assist Maneuver is Successful
- 5º Rudder Failure at 10 kts in Rosario Straits – Assist Maneuver is NOT Successful
- 10º – 35º Rudder Failure at 10 in Rosario Straits – Assist Maneuver is Successful
- 5º & 10º Rudder Failures at 12 kts in Rosario Straits – Assist Maneuver is NOT Successful
- 15º - 35º Rudder Failures at 12 kts in Rosario Straits – Assist Maneuver is Successful

An Engineered Solution Exists that can Prevent a Grounding

However, Human Factors Govern the Probability of Success

Probability of Grounding – Redundant System Tankers

Engine Failure Frequency = ~ 5 in 10,000 (based on Puget Sound VTS Incident Reports)

Rudder Failure Frequency = ~ 4 in 10,000 (based on Puget Sound VTS Incident Reports)

Two Engine Failure Frequency = ~ 25 in 100,000,000 (2.5×10^{-7})

Two Rudder Failure Frequency = ~ 16 in 100,000,000 (1.6×10^{-7})

One Rudder Failure & One Engine Failure Frequency = ~ 20 in 100,000,000

Rate is per Transit

Preliminary Conclusions:

- **One Engine Failure** (leaving 1 engine & 2 rudders) **– Grounding can be Averted**
- **One Rudder Failure** (leaving 2 engines & 1 rudder) **– Grounding can be Averted**
- **Two Rudder Failures** (leaving 2 engines) **– Grounding can NOT be Averted**
- **One Rudder & One Engine Failure – Grounding can be Averted**
- **Two Engine Failures** (leaving 2 rudders) **– Grounding can NOT be Averted**

Thus Probability of Grounding = ~ $2.5 \times 10^{-7} + 1.6 \times 10^{-7}$ = ~ 4.1×10^{-7}

Probability of Grounding – Single Screw Tankers

Engine Failure Frequency = ~ 5 in 10,000 (based on Puget Sound VTS Incident Reports)

Rudder Failure Frequency = ~ 4 in 10,000 (based on Puget Sound VTS Incident Reports)

Given the above IFs the Probability of Grounding = ~ Zero

- **Therefore, Single Screw Tankers with Escort are less likely to ground then Redundant System Tankers without Escort (0 is less then 4.1 x 10^{-7})**
- **However if Human Factor Errors are greater than 5 in 10,000 then Redundant System Tankers without Escort are less likely to ground than Single Screw Tankers with Escort**
- **The Human Factors are more complex for Single Screw Tankers with Escort then Redundant System Tankers without Escort**

Human factor risks will be further developed and discussed in subsequent presentations and reports.

IMO Oil Outflow Methodology

Hypothetical outflow of Oil (IMO MARPOL 73/78 Regulation 23) requires outflow calculations for side and bottom damage

Acknowledgment: Risk Does Exist

Assumption: Vessel has been involved in a casualty event, breeching at least one tank

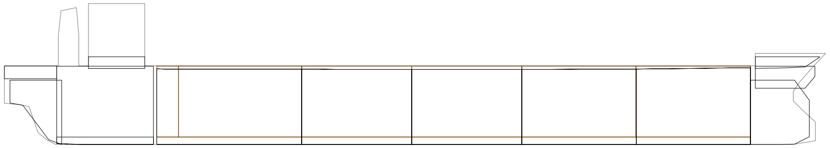
Methodology:

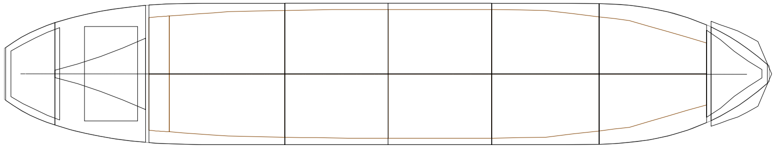
- Determine the probability of damage extent (once damage has occurred)
- Calculate the resulting consequences

This is accomplished by the following steps:

- Establish the Intact Load Condition
- Assemble Damage Cases
- Compute the Oil Outflow for Each Damage Case
- Compute the Oil Outflow Parameters
- Compute the Pollution Prevention Index “E”

The oil outflow calculation will be explained in more detail in subsequent presentations and reports.





Oil Outflow for Double Hull Tankers

Oil Outflow for Suez Max. Double Hull Single Screw Tankers

is approximately equal to

Oil Outflow for Suez Max. Double Hull Twin Screw Tankers

Oil Outflow for Partially Loaded Tankers is Greater than for Fully Laden Tankers (depending on loading configuration)

Oil Outflow for ATC and Polar tankers (with 3 meter double hull) loaded to 125,000 dwt will be Greater then Oil Outflow for IMO minimum compliance Suez Max. tanker (with 2 meter double hull) loaded to 125,000 dwt

These results will be check and verified by Herbert Engineering Corporation before publication in the final report.

Preliminary Conclusions

The <u>Probability</u> of Oil Outflow for Redundant System Double Hull Tankers without Escort

is less than

the <u>Probability</u> of Oil Outflow for Single Screw Double Hull Tankers with Escort

This preliminary conclusion is based on an assumption about human factor error rates and compensating measures that could be implemented for the auxiliary functions of an escort tug. These issues will be further evaluated and presented in subsequent presentations and reports.

Preliminary Conclusions

Revisions to the Washington State Tug Escort Regulations that should be considered:

- **Changing the requirement for tug escort for redundant system tankers (perhaps weather and/or waterway dependent)**
- **Define capability requirements for redundant system tankers (perhaps using ABS's notation R2S and / or R2S+)**
- **Add a performance requirement for tug - tanker escort taking into account tanker speed, weather, width of waterway and other factors, similar to OPA 90 part (a)**
- **Evaluate the consequence of dual loadlined tankers**
- **Compensating strategies for the loss of auxiliary escort tug functions (navigation, firefighting, first spill response)**

Other issues including the introduction of risk by escort tugs, the migration of risk and risk management factors will be evaluated and discussed in subsequent presentations and reports.